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ABSTRACT

This paper describes the status of NASA's Space Infrared Telescope Facility (SIRTF) program. SIRTF will be a cryogenically cooled observatory for infrared astronomy from space and is planned for launch early in the next decade. We summarize a newly modified SIRTF baseline, which is to be launched into a heliocentric orbit by an Atlas IIas rocket, and provide an overview of SIRTF's scientific programs.

INTRODUCTION

SIRTF – the Space Infrared Telescope Facility – has been planned by NASA as a cryogenically cooled observatory for infrared astronomy from space. SIRTF will build on the scientific and technical basis established by the successful IRAS and COBE missions and also on the results of the European Space Agency's forthcoming ISO mission. However, SIRTF will go beyond these precursor cryogenic space missions by making extensive use – for both imaging and spectroscopy – of the large-format infrared detector arrays now coming into use for astronomical applications. SIRTF is envisioned as a multi-user facility with a broad range of capabilities. The scientific potential of a cryogenic space observatory equipped with state-of-the-art infrared detector arrays is so compelling that SIRTF was designated in 1991 both as the highest priority astronomy mission for the 1990s by the National Academy of Sciences, and as NASA's highest priority "flagship" scientific mission by the interdisciplinary Space Science and Applications Advisory Committee.

The SIRTF science and engineering teams have worked over the past year to define a new mission concept which maintains much of the scientific power of the original mission but is considerably smaller, simpler, and less expensive. At the same time, we have continued to push ahead with the detector development activities which, as mentioned above, will be the source of SIRTF's greatest scientific gains. This paper provides a brief overview of the new SIRTF concept and a summary of the SIRTF science program. Much more detailed descriptions of the new mission and the instruments have been published recently[1,2] and details of the SIRTF science program are given elsewhere[3-6].

THE NEW MISSION

1. Orbit

A key step in the development of the new SIRTF concept came with the realization that an Atlas IIas rocket could launch a 2500-kg spacecraft into a solar orbit – in which the spacecraft escapes from the Earth's gravity but is captured by the Sun and drifts slowly away, achieving a distance of about 0.6 AU from the Earth after five years. This orbit makes better use of launch capability than does a conventional Earth orbit because it is no longer necessary to circularize the orbit. In addition, the solar orbit provides an excellent thermal environment because of the absence of heat input from the Earth, as well as excellent, uninterrupted viewing of a large portion of the sky. It does require a different strategy for communication; for the new SIRTF concept, this has been solved by installing a fixed 1.5-m antenna on the bottom of the spacecraft. Downlinks will be accomplished by orienting the spacecraft so that the antenna points toward the Earth and sending the stored data down at a high rate to stations of NASA's Deep Space Network. This allows an average data rate of 45 kbps – corresponding to one image from

SIRTF's largest array every seconds wi h only a several percen loss of e ciency due to the downlink process.

2. *Instruments*

The mass, size, and cost constraints of the Atlas mission required a reduction in scope and complexity of the three instruments which are under definition study for SIRTF (Table 1). The current capabilities are summarized in Table 2, which shows that the SIRTF instruments will provide both imaging and spectroscopy at all wavelengths from 2.5 to 200 μm. The detectors to be used in all cases will be arrays in formats up to 256x256. Note from Table 2 that, in a given wavelength band, the same detector material and array architecture is to be used for both imaging and spectroscopy. This has led to a streamlined detector technology program(7) in which separate development paths for spectroscopic and imaging detectors have been eliminated in order to maximize the use of scarce fiscal and human resources. Table 2 also lists, for each instrument module, one of the key scientific areas to which it can be applied. This tabulation is indicative of the breadth of SIRTF's scientific programs.

3 *Use of arrays*

Each of the three instruments exploits in a different way the possibilities inherent in the detector arrays; for example, the IRAC will use a dichroic beamsplitter to separate the incident infrared radiation into short wavelength [2.5-5.5 μm] and long wavelength [5.5-28 μm] bands; the two bands are then separately imaged on the InSb and Si:As detector arrays, respectively. Thus, all IRAC observations will be made simultaneously at near- and mid-infrared wavelengths, increasing the efficiency of data collection and facilitating registration of images made at different wavelengths. In addition, the IRAC will incorporate a grism to be used for low resolution spectroscopy from 2.5 to 5 μm; the grism-array combination is particularly powerful even when used in combination with a slit because it allows spectra to be obtained simultaneously of several objects or at many points in the field.

The MIPS will also use a dichroic to permit simultaneous imaging in two of its three bands the Si:Sb channel from 15-40 μm and the Ge:Ga [stressed] band from 120-200 μm. In addition, the MIPS incorporates a scanning mirror which can be scanned in opposition to a constant motion of the telescope to freeze an image of the sky on its arrays. Operation of this scan mirror in a sawtooth mode allows adjacent fields on the sky to be imaged without starting and stopping the motion of the entire telescope. This "step-scan" mode has been demonstrated at 2 μm in ground-based feasibility studies for the Two-Micron All Sky Survey [2-MASS](8) project. It provides a very efficient means for SIRTF to survey large areas of the sky at integration times of 10 to 30 seconds per field, which will reach typical sensitivity levels 100 times fainter than the IRAS Faint Source Survey.

The IRS will illuminate the 128x128 Si:As and Si:Sb arrays in a cross-dispersed echelle mode, typically having 10 spectral orders displayed on the array simultaneously. In many cases, this will allow lines which are close in wavelength such as the NeII, III, and V lines discussed below to be measured simultaneously. This assures accurate relative spectrophotometry. It will also allow complete 4 40 μm spectra to be obtained efficiently with only a few settings of the predisperser gratings.

4. *Telescope and spacecraft*

The SIRTF optical and cryogenic systems, as well as the spacecraft, were also refined to meet the constraints of the Atlas mission. Through a process of iteration and first-order optimization, we arrived at the telescope-dewar system shown in Fig. 1. The telescope will have a lightweight 85-cm diameter primary and a fixed secondary. The primary f-ratio is f/1.5, and the system f-ratio is f/12. The telescope is a Ritchey-Chretien Cassegrain, and the instruments are located in the multiple instrument chamber behind the primary mirror. The instruments share a 26-arcminute-diameter field of view. Telescope and instruments together are packaged within a 1000-liter annular helium tank, which provides a minimum cryogenic lifetime of three years. This represents a significant reduction from the previous five-year lifetime, and it appears that additional optimization and refinement of the cryogenic design may increase the lifetime further.

The spacecraft concept for the Atlas mission is shown in Fig. 2, where it is compared both with the previous Titan-launched SIRTF and with IRAS and ISO. This figure shows dramatically the reduced size and mass of the new SIRTF system. The SIRTF spacecraft shows the bottom-mounted communications antenna referred to above. The fine guidance telescope mounted on the outer shell of the cryostat will provide the overall 0.25 arcsec pointing stability required by SIRTF's instruments. It will be supplemented by several quadrant sensors within the instrument chamber which will be used for boresight and alignment updates. The spacecraft will use reaction wheels for slew maneuvers and a cold gas system for momentum dumping. Other spacecraft subsystems communications, data handling, power, and structures are well within the current state of the art.

The top-level characteristics of the Atlas mission are summarized in Table 3. The combination of the long lifetime, 85-cm aperture, and large, sensitive detector arrays will give this mission great power for the study of known astrophysical phenomena including problems to be defined by ISO and for exploring the Universe at infrared wavelengths at unprecedented sensitivity levels. This is illustrated in Fig. 3, which compares the sensitivity expected for SIRTF with the levels reached in the IRAS Faint Source Survey and with the predicted brightness of typical targets of the deep surveys described below.

III. SIRTF SCIENCE

SIRTF will bring a wide range of capabilities to bear on important scientific problems in all area of astrophysics, including as yet undefined problems which will arise from other missions, most notably IRAS and ISO, but also HST and COBE. Although the details of the SIRTF scientific strategy are only now being defined, we can expect that many of SIRTF's most important scientific advances will be the results of systematic programs carried out in a survey mode, including both targeted and unbiased surveys with both spectroscopic and imaging instrumentation. In addition to the particular scientific problems discussed below which can be addressed in this fashion, we can anticipate confidently that these surveys, which will probe the cosmos to unprecedented depths at infrared wavelengths [cf. Fig. 3] will lead to the discovery of new and important astrophysical phenomena.

1. Targeted surveys

It is often important to observe numerous examples of a particular phenomenon in order to understand the underlying physical mechanisms and their significance. SIRTF will carry out targeted surveys for the purpose of building up a data base which can be used to develop this type of understanding of specific scientific problems. A good example of this would be in studies of planetary debris disks- the Vega phenomenon which rank as one of the most significant discoveries of the IRAS mission[9,10]. The results from IRAS suggest that shells or disks of dust are associated with perhaps 50 percent of" solar-type main sequence stars, and detailed study of the brightest few examples indicates that these dust disks are indicative of the occurrence around other stars of condensation and coagulation phenomena perhaps similar to those which produced the planets in our Solar System.

A full understanding of this phenomenon and its relation to planetary formation requires both detailed imaging and spectroscopic studies of numerous examples plus a census of the occurrence and properties of such disks around stars of various spectral types, apparent ages, rotation rates, etc. ISO will make progress in developing this understanding. SIRTF, with its ability to see such disks around stars as distant as several kpc and to image them at wavelengths around 30 μm where the central voids suggestive of embedded planets should be most apparent, can provide an enormous data base for further exploration. Doing this properly would, however, require a targeted survey; that is, a program of systematic observations of a large and carefully selected sample of stars. Other targeted surveys from SIRTF might focus on spectroscopic measurements, such as systematic programs to develop spectral atlases of active galactic nuclei or of asteroids and planetary satellites. Further targeted surveys will certainly be defined during the SIRTF mission, based on the results obtained in unbiased surveys such as those described below.

2. *SIRTF deep surveys*

In addition to the fast surveys described above, SIRTF will be used extensively for deep surveys with integration times of hundreds or thousands of seconds per field of view. Indeed, such an exploration of the Universe at levels set only by the Earth's natural astrophysical environment is fundamental to the scientific rationale for SIRTF. Such surveys will be designed in detail to attack the scientific questions considered of highest priority at the time of the SIRTF mission and will also be synergistic with the surveys to be carried out in other spectral bands. We discuss below four of the scientific problems that SIRTF's deep surveys might address.

a. A search for Kuiper-belt comets

The Kuiper belt is a hypothesized disk of planetesimals located in the plane of our Solar System beyond the orbit of Neptune (r>35 AU); its existence is inferred from the orbital statistics of a particular family of comets(11,12). Direct observations of objects in the Kuiper belt could verify this conjecture and perhaps provide a link between the outer regions of our Solar System and the planetary debris disks around nearby stars which will also be studied by SIRTF.

In the past several years these speculations have been placed on a much firmer foundation by the discovery by Jewitt and Luu(13,14) and by Luu(15) of two objects having the predicted characteristics of Kuiper belt planetesimals. The first of these, 1992QB1, is a very red solid body at a heliocentric distance of about 41 AU, with an orbit of low inclination (2.22 deg) and moderate eccentricity (0.107). The perihelion distance is 39.6AU and the period is 295.7 years. The second object, designated 1993FW, has a semimajor axis of 42.5 AU and an inclination of 8 deg. These objects have visual magnitudes around +23.5.

If the geometric albedo of these two bodies is 0.05 at 0.55 μm, they will be at a temperature of 50K, and their diameters are about 200 km. The predicted flux of these objects at 100 μm is 2mJy, which is easily detectable by SIRTF. It would require about 20 hours to survey one square degree to this sensitivity level, during which time any objects that are in fact 40 AU from the Sun would appear to move about 1.4 arcmin because of the motion of the spacecraft. Thus a second 20 hours of observation could pick out any candidate Kuiper belt bodies from background objects such as distant galaxies and wisps of interstellar dust. It is clearly possible with SIRTF to detect or set limits on such objects which lie in the range of existing optical surveys and also within the uncertainty band of the theoretical predictions(10) shown in Fig. 4. SIRTF surveys would be uniquely sensitive to objects with albedo <0.05 which could go unseen at optical wavelengths.

b. Brown dwarfs

Brown dwarfs are hypothetical objects with masses between 0.001 and 0.08 M(Sun) which are too low in mass to ignite nuclear burning but which might be visible in the infrared as the heat generated in their collapse is radiated away. Such objects have stubbornly eluded detection in a number of searches(16). Recently, however, Nelson, Rappaport and Joss(17) have reviewed the theoretical and observational uncertainties and concluded that "for reasonable theoretical assumptions", the current limits would still allow brown dwarfs to contribute significantly to the mass of the disk of our Galaxy.

As brown dwarfs cool and age, their infrared emission shifts inexorably into the thermal bands where SIRTF's sensitivity advantage is the greatest. Nelson et al[17] present dynamically interesting models predicting about one hundred brown dwarfs per square degree with 10 μm magnitude +17.5. If such brown dwarfs have temperatures lower than 1000 K, corresponding to a relatively old, low-mass population, then they would be very faint shortward of 3 μm, and observations from SIRTF will be uniquely important in searching for them (Fig. 3). At this level, there would be about one such object in each SIRTF deep survey image made in the 10 μm region. The image obtained simultaneously with the IRAC at 3-5 μm would permit rapid selection of low temperature candidate objects for further study.

c. *The evolution of the infrared galaxy luminosity function*

IRAS provided our first complete look at the extragalactic sky in the infrared and showed that more than half of the luminosity of a typical spiral galaxy emerges at far infrared wavelengths between 40 and 120 μm. As detailed by Soifer[18], the far infrared luminosity of galaxies can exceed 1e+12 L(Sun), well into the luminosity range previously reserved for quasars. IRAS also revealed a previously unsuspected association between galaxy-galaxy interactions and enhanced infrared luminosity. The ultra-luminous galaxies- those having L>1e+12 L(Sun) have optical images suggestive of violent interactions and mergers. Similarly, infrared-luminous galaxies- those having L(ir)>L(vis) are more common among galaxies with close companions or evidence of tidal distortions than among field galaxies. Taken together, and with supporting optical spectroscopy and radio astronomical studies, these data suggest that interactions between galaxies can trigger starbursts, concentrate molecular gas in galactic nuclei, and initiate the accretion of matter by (perhaps pre-existing) black holes.

The "no evolution" model shown in Fig. 5 predicts about 700 galaxies per square degree brighter than 1 mJy at 60 μm, while the most extreme evolutionary model predicts about 5000. Thus, a SIRTF deep 60-μm survey of a few square degrees can not only demonstrate conclusively that evolution does (or does not) occur but also distinguish among various evolutionary scenarios. Using the 5x5 arcmin Ge:Ga array at 60 μm, it will take about 20 hours to survey one square degree to noise levels significantly below 1 mJy. As pointed out by Hacking and Soifer[19] and other investigators, the sensitivity of SIRTF or any other telescope for deep surveys will be limited eventually by "confusion" due to background brightness fluctuations resulting from statistical variations in the number of faint sources in adjacent beams. Because the structure of the sky emission at such low flux levels provides information about the distribution of distant galaxies beyond that which can be dervied from the observable luminosity function, SIRTF's deepest surveys will be designed to reach levels where these confusion effects become very signficant. Recent simulations by Rieke[20] suggest that at 60 μm this is at a level of about 50 uJy, which requires about 10,000 seconds of integration to achieve. At 60 μm, it will also be possible to execute such ultradeep surveys with pixels that fully sample the point spread function; post-processing of the resulting images can increase the effective resolution beyond the Rayleigh criterion and probe still farther into the structure of the infrared sky.

Although infrared continuum observations are essential to determine the luminosity of these ultra-luminous galaxies, many of which have L(ir)>>10L(vis), spectroscopic diagnostics are the only means of studyi ng the p ropei ties of the unde rly ing ei iergy sources and distinguishing starbursts from active galactic nuclei. For an object with 1 .(ir)>>1 01 .(vis), there is no guarantee that any of the visible w avelength emission lines orig inate anywhere near the principal luminosity source., and even near infrared lines m ay well suffer sig nificant extinction. Therefore, spectroscopic observations at longer infrared wavelengths have a unique role to play in the characterization of the luminosity sources in these galaxies. Voit[21] has recently called attention to a group of neon fine-structure emission lines, arising from ionization states between NeII and NeVI, which cluster together at wavelengths between 7.6 and 36 µm. of particular note are three lines of NeII, NeIII, and NeV, which lie at 12.8, 15.6, and 14.3 µm, respectively. These fall in a minimum in the extinction curve- between two silicate absorption bands- and suffer little differential extinction even wh en viewed through the equivalent of 1 00 magnitudes of visual extinction. In addition, whereas NeII is common in ordinary HII reg ions, NeV is produced by photons of energy 100ev, so that the ratios of these lines can distingu ish very well between starburst and AGN models. SIRTF's spectrograph, using a large array in cross-dispersed echelle mode, can measure the lines simultaneously to minimize concerns about pointing and aperture size corrections. This type of spectroscopic diagnostic promises 10 be extremely powerful, and Voit snows in greater detail how the full range of Ne lines can be used to determine density and temperature- as well as excitation conditions in astrophysical plasmas.

In addit ion to answering questions about the evolution of infrared-luminous galaxies, S1 RTF's deep 60-µm surveys will provide catalogs of interesting targets for further examination, either with SIRTF's own spect rograph or from ground-based optical and radio telescopes. A particularly exciting result of such follow-on observations could be the discovery of additional objects similar to the spectacular protogalaxy candidate FSC+ 10214 found in the IRAS Faint Source Survey[18, 22, 23]. As shown in Fig. 3, SIRTF could detect such objects at redshifts greater than 10.

d. Deep near-infrared surveys

Another, complementary look at the extragalactic sky can be obtained by SIRTF through a deep survey in the background minimum around 3.5 µm (Fig. 6). At this wavelength, the InSb array can reach flux levels around 1µJy (2 1st magnitude) in 500 seconds of integration. Based on the results obtained by Cowie et al[24], a single 5x5 arcmin field measured to this level at 3.5 µm could contain upwards of 1 000 galaxies, many of which would have z>l. Thus a survey of a small area on the sky would yield a very large sample of galaxies.

Number counts at these flux levels would be of interest, but the addition of redshift information would allow exploration of the luminosity function and cl ustering properties of galaxies at various redshifts. SIRTF's own observations can contribute to the determination of redshift estimates for these galaxies by searching for the broad maximum predicted to appear at a rest wavelength of around 1.6 µm in the energy distribution of galaxies once they contain sig nificant numbers of red giants[25, 26, 2“]). Spectral energy distributions at (rest) wave.lc]lf,tlls from 0.5 to 2 µm are required for these redshift estimates. For redshifts greater than 1, these will require SIRTF images to wavelengths of 5 µm and beyond, supplemented by deep ground-based images in the optical and near infrared. For nearby galaxies, the ground- base.d images will be most important, with the S11<'1'1; observations providing additional constraints. This is a good example of the potential synergism between deep surveys from SIRTF and those obtained from other tclc.scopes; the results could provide important constraints on the evolution of galaxies and of larf}c-scale structure in the early Universe.

SIRTF's extragalactic surveys will be coordinated with ground-based optical, near- infrared, and submillimeter surveys to provide a spectrally broad picture of the extragalactic sky. This broad picture can be compared with a new generation of galaxy evolution models which include formation of dust and its subsequent absorption of starlight and far infrared emission in addition to the usual time variation of the stellar populations. Early models of this type, developed by Chokshi et al[28] following the methodology of Chokshi and Wright[29] have reproduced the observed IRAS counts at 60 µm[30].

Another potentially impel-tanl application of deep 3.5-μm surveys has become apparent with the release of the data from the DIRBE experiment on the COBE spacecraft, which measured the infrared backgrounds from 210240 μm with unprecedented sensitivity. These measurements[31] determined that the background brightness at the 3.5-μm minimum is vI(v) = I .5E- 11 w/cm+2/sr, and, as shown in Fig. 6, [his minimum is [he. place (o search not only for distant point source.s but also for any diffuse component in the background. The DIRBE data analysis is intended to remove the foreground emission from solar system and galactic sources with sufficient accuracy that the extragalactic background at 3.5 μm can be determined with an uncertainty of 1 % of this, or 1 .51;-13 w/cm+2/sr. This will include contributions from point sources [i c., galaxies], as well as any truly diffuse component, averaged over DIRBE's 0.6 degree beam. Within a single DIRBE beam, SIRTF will be able. to measure. all the point sources down to 1 uJy at 3.5um, at which level it is expected that the integrated flux from galaxies will have begun to converge. Wright[32] has estimated based on Cowie's work and typical galaxy colors that the contribution due to the galaxies which SIRTF can measure will be about 3,411-13 w/cm+2/sr, greater than the uncertainty with which DIRBE can determine the background. Depending on the results of DIRBE's measurements, SIRTF's observations could be of crucial importance in constraining?, or verifying the existence of a diffuse. extragalactic background, which would be of great scientific interest.

IV. IMPACT OF THE SHORTENED MISSION

Perhaps the biggest scientific impact of the. move from the Titan SIRTF to the Atlas SIRTF is the reduction of the cryogenic lifetime from five to three years. This is potentially a greater loss than the. 40 percent reduction in observing time would suggest, because it also reduces the amount of time that wil I be available for contemplating the. initial results from SIRTF and folding the.m into **follow-on** observational programs. The potential loss of such opportunities is particularly **critical** in **this** case because SIRTF is so sensitive that many of its discoveries will not be detectable from other platforms, just as many of IRAS' results will go unexplored at least until the launch of ISO.

To compensate for this loss of "thinking time.", we are planning a scientific strategy for SIRTF which will emphasize the surveys discussed above- both targeted and unbiased- in the first six months to one year of the mission. The data from the.se. surveys will be made widely available in a timely fashion so that many scientists can start at once to understand its significance and also to use it as a basis for follow-cm investigations from SIRTF. This type of broad participation is consistent with SIRTF's role as an observatory for the entire scientific community; in addition, we intend to make the community's role a very active one by soliciting widespread participation in defining and executing these early surveys.

V. CONCLUSIONS

The capabilities and challenges of SIRTF combine. [0 make it an appealing and challenging mission on both scientific and technical grounds. The scientific, technological, and engineering groundwork for this exciting step in the exploration of the Universe have been established by many years of work in the academic, government, and aerospace communities. We. are ready and eager to move forward on a schedule calling for a Phase B start in 1995, leading to a Phase C/D start in 1997 and launch in 2001 or 2002.

VI. ACKNOWLEDGMENTS

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'1'able. 1. Silt'1'li Instruments

Infrared Spectrograph (IRS)	P.I.: Dr. J. Houck, Cornell University

Will obtain infrared spectra with R-1 000-2000" covering the wavelength interval from 410200 pm.

Infrared Array Camera (IRAC)	1'. 1.: Dr. G. Fazio, Smithsonian Observatory

Will provide wide field (5' x 5') and diffraction-limited imaging over the spectral region 2.5 to 28 pm. Grism spectroscopy, 2.5-5 pm. Polarimetric capability.

Multiband Imaging Photometer (MIPS)	P. I.: Dr. G. Rieke, Arizona University

Will provide wide field (5' x 5') and diffraction-limited imaging over (he spectral region 15 to 120 μm and 0.6' x 5' imaging over the spectral region 120 to 200 μm. Polarimetric capability.

Table 2. Instrument Capabilities - Atlas SIRTF

a. imaging Instrumentation

Wavelength Range (µm)	Material/ Array Size	Field of View/ Pixel Size	Unique Science
2.5 -5.3	InSb 256 x 256	5' x 5' 1.2"	Protogalaxies
4-28	Si:As IBC 128x128	5' x 5' 2.4"	Brown dwarfs
15-40	Si:Sb IBC 128x 128	5' x 5' 2.4"	Planetary debris disks
40 - 120	Ge:Ga 32 x 32	5' x 5' 9.0"	Interacting galaxies
120-200	Ge:Ga (stressed) 2 x 16	0.6' x 5' 19.0"	Early stages of star formation

b. Spectroscopic Instrumentation

Wavelength Range (pm)	Material / Array Size	Spectral Resolving Power	Unique Science
2.5- 5"	InSb 256 x 256	200	Composition of solar system objects
4-12	Si:As IBC 128x128	2.000 (cmss-dispersed)	Composition of interstellar material
12-40	Si:Sb IBC 128x 128	2000 (cross-dispersed)	Nature of galactic nuclei
40-120	Ge:Ga 4x32	2000	Star formation
120-200	Ge:Ga (stressed) 2x16	1000-2000	Composition and energetics of interstellar clouds

*Capability provided by grism in camera.

“1’able 3. ‘1’op-level characteristics of Atlas SIRTF

	Atlas
Orbit	solar
1 ,ifetime	3 years minimum
Aperture	85 cm
wavelength Coverage	2.5-200 pm
Data Rate	45 kbps
Secondary Mirror Articulation	no
Pointing Stability/ Accuracy	0.25 arcsec/0.25 arcsec
Image Quality	2 arcsec
Mass	2500 kg

'1'able 1. SIRTF instruments

Table 2. instrument Capabilities - Atlas SIRTF

a. imaging Instrumentation

b. Spectroscopic Instrumentation

'1'able 3. '1'op-level characteristics of Atlas SIRTF

Fig. 1. Cutaway view of the telescope-dewar system for the ATLAS SIRTF

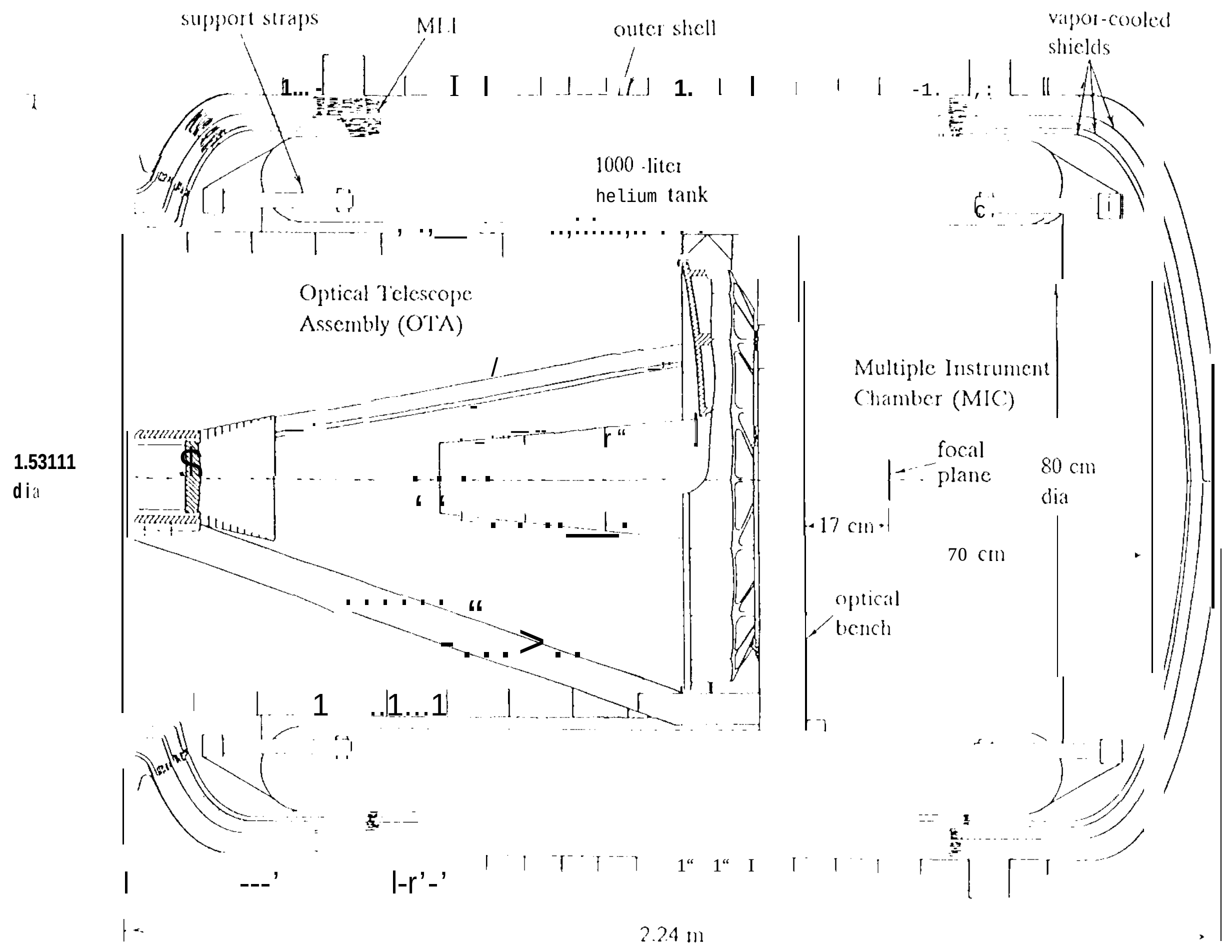
Fig. **2.** Comparison of the Atlas SIRTF observatory with the previous Titan SIRTF concept and with 1S0 and IRAS. The spacecraft arc shown to scale, and the mass and cryogenic capacity for each is shown as well.

Fig. 3. The photometric sensitivity to be achieved by SIRTF across the infrared band is compared with the predicted brightness of the tar-gets of the SIRTF deep surveys and with the 1 -sigma sensitivity limits of the IRAS Faint Source Survey. The SIRTF sensitivity estimates are 1-sigma in 500 seconds; they are based on demonstrated detector performance or current expectations and include both natural background and (at the longer wavelengths) confusion limits. The survey targets arc: a Kuiper belt object with 100-km radius, 40 AU from the Sun; a 1000-K brown dwarf with 10-pm magnitude of +17.5; the IRAS candidate protogalaxy FSC10214 as seen at a redshift z= 10; and a model protogalaxy assuming 1e+ 11 solar masses of star-s arc formed at a constant rate for 0.8 Gyr prior to observation at z=5. The adopted FSC 10214 energy distribution is a straight line interpolation between the fluxes detected at 2.2 and 60 pm. A cosmological model with omega = 1 and a Hubble constant of 50 km/sec/Mpc arc assumed.

Fig. **4.** Limits on the number density pcr square degree of Kuiper belt objects brighter than visual magnitude V (99 percent confidence limits) as established by a number of optical surveys —see Tremaine[11] for the original references from which the plotted limits arc derived. The circled cross shows the type of object which SIRTF could detect in a deep ecliptic plane survey at 100 μm which is very similar to the candidate Kuiper belt objects recentl y announced by Jewitt and Luu[13-15]. The upper and lower diagonal lines represent estimates of the expected number of objects pcr unit solid angle brighter than V for two extreme theoretical models discussed by Tremaine.

Fig. 5. Predicted galaxy flux vs. number counts at 60 μm for several models of the evolution of the 60-μm luminosity function. The limiting flux attainable by SIRTF at 60 μm (3σ in 500 sec) is shown. See Hacking and Soifer[19] for further details.

Fig. 6. COBE follow-up. The data[31], taken from measurements by the DIRBE instrument on the COBE spacecraft, show a minimum in the infrared background emission at 3.5 μm. Much of this emission at 3.5 μm comes from the solar system or' the galaxy, but the DIRBE science team will correct for this foreground emission and determine any extragalactic background with an uncertainty of 1 percent of the total brightness, or 1.5 x 10-13 w/cm^2/sr. This determination will include both the contributions of galaxies within DIRBE's 0.6-degree beam and of any truly diffuse extragalactic background. SIRTF can measure the contributions of the galaxies, and the extrapolated brightness due to galaxies is expected to be 3 x 10^{-13} w/cm^2/sr down to SIRTF's detection limit. The SIRTF observations can thereby constrain or verify the presence of this background, which would be of great scientific interest.



support straps
MLI
outer shell
vapor-cooled
shields
1000 -liter
helium tank
Optical Telescope
Assembly (OTA)
Multiple Instrument
Chamber (MIC)
focal
plane
80 cm
dia
17 cm
70 cm
optical
bench
2.24 m

Fig. 1

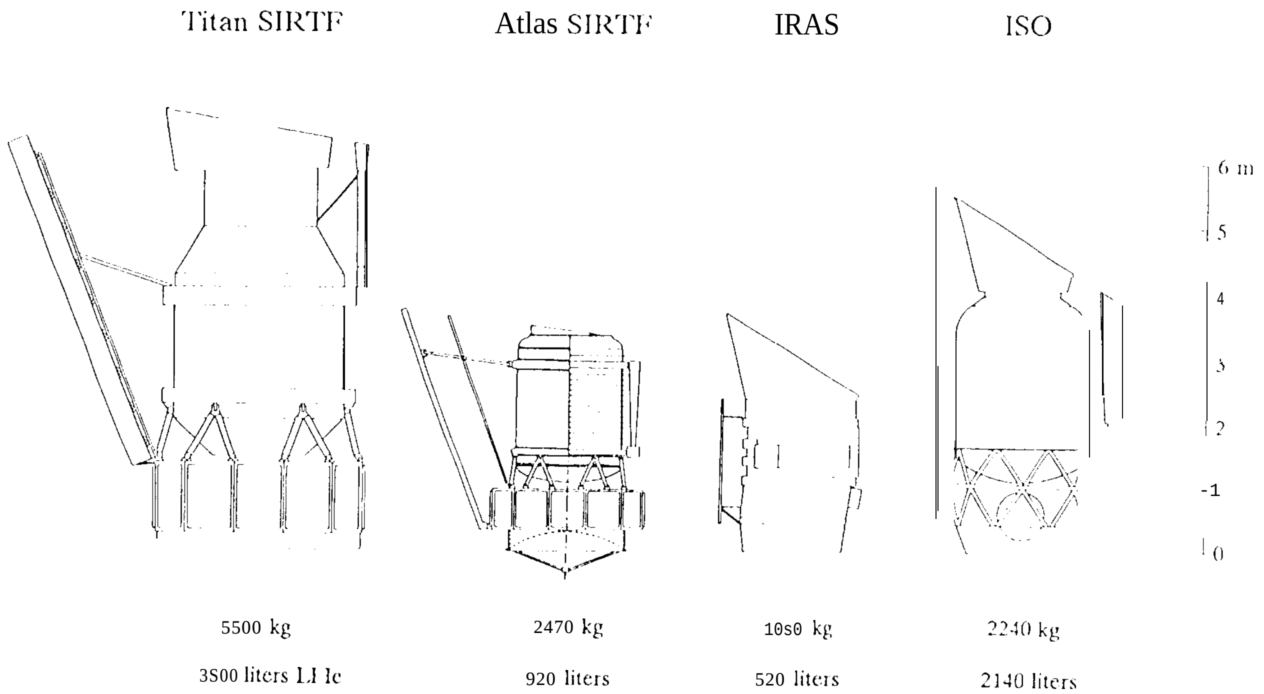

Titan SIRTF
Atlas SIRTF
IRAS
ISO
6 m
5
4
3
2
1
0
5500 kg
3800 liters LHe
2470 kg
920 liters
1080 kg
520 liters
2240 kg
2140 liters

Fig. 2

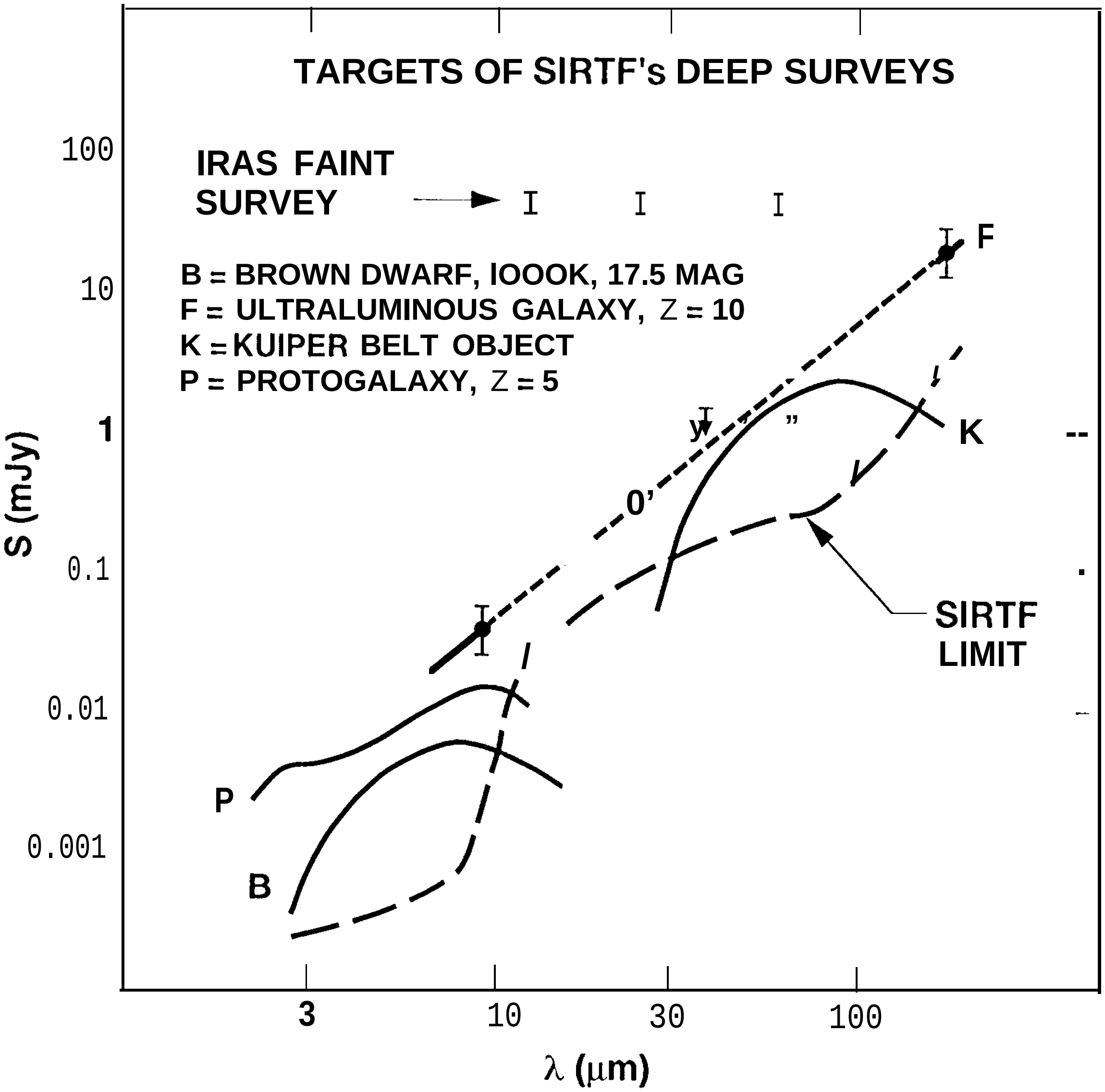
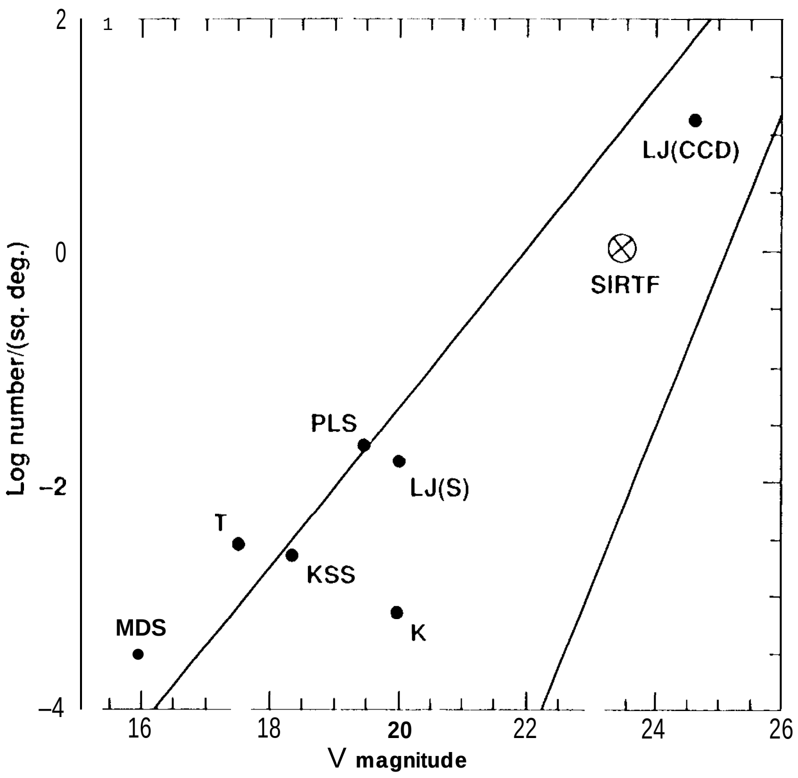

TARGETS OF SIRTF's DEEP SURVEYS
IRAS FAINT SURVEY
B = BROWN DWARF, IOOOK, 17.5 MAG
F = ULTRALUMINOUS GALAXY, Z = 10
K = KUIPER BELT OBJECT
P = PROTOGALAXY, Z = 5
F
K
P
B
SIRTF LIMIT
S (mJy)
100
10
1
0.1
0.01
0.001
3
10
30
100
λ (μm)

Fig. 3



Log number/(sq. deg.)
2
0
−2
−4
16
18
20
22
24
26
V magnitude
LJ(CCD)
SIRTF
PLS
LJ(S)
T
KSS
MDS
K

Fig. 4.

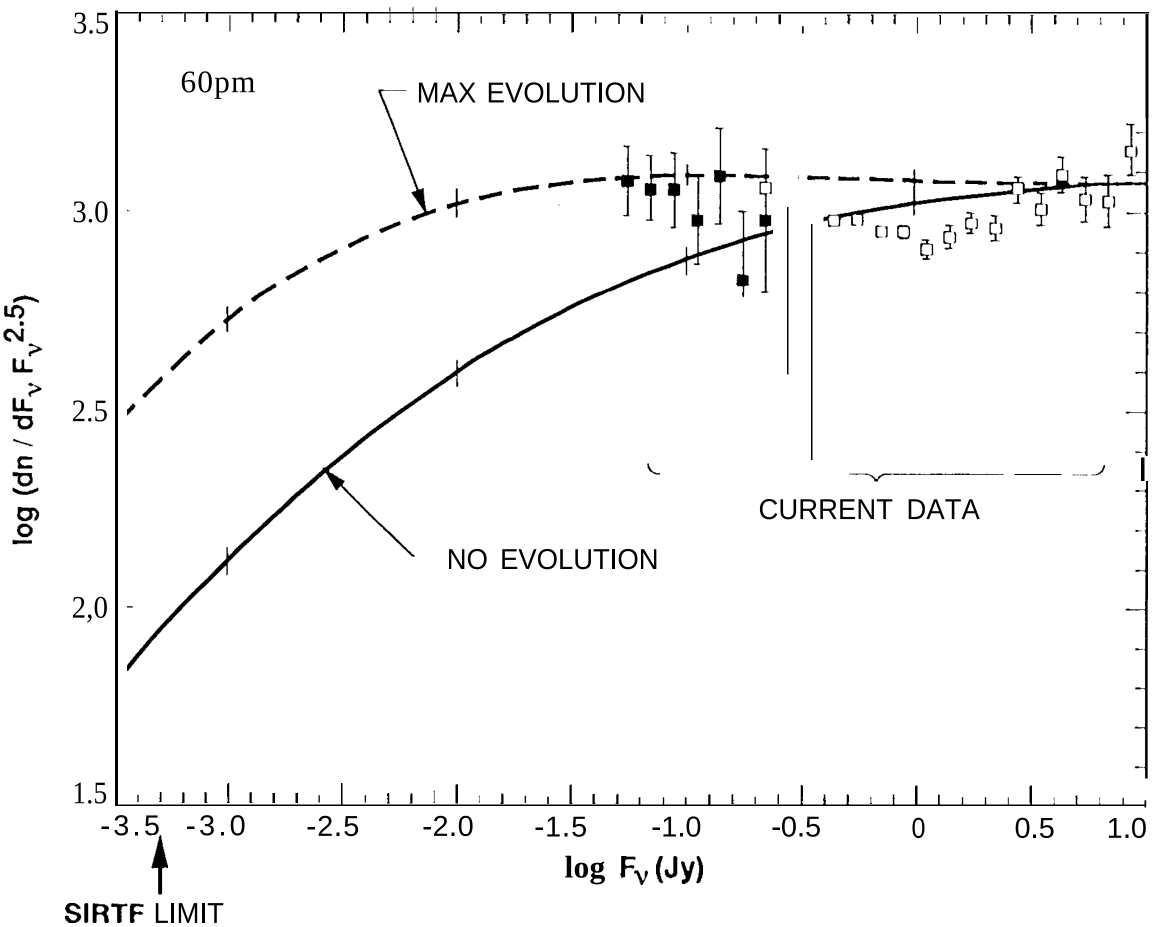

60pm
MAX EVOLUTION
NO EVOLUTION
CURRENT DATA
log (dn / dF$_\nu$ F$_\nu^{2.5}$)
log F$_\nu$ (Jy)
SIRTF LIMIT
3.5
3.0
2.5
2,0
1.5
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0
0.5
1.0

Fig. 5.

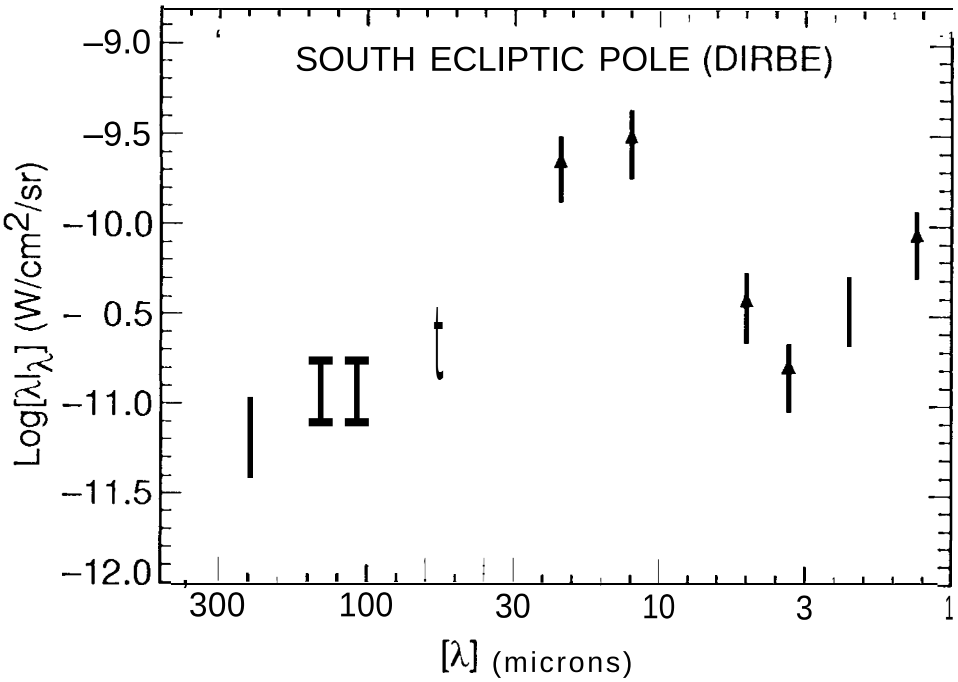

SOUTH ECLIPTIC POLE (DIRBE)
−9.0
−9.5
−10.0
− 0.5
−11.0
−11.5
−12.0
Log[λIλ] (W/cm2/sr)
300
100
30
10
3
1
[λ] (microns)

Fig. **6.**